NASA SBIR Select 2012 Phase I Solicitation

E3.01 Laser Transmitters and Receivers for Targeted Earth Science Measurements

Lead Center: LaRC

Participating Center(s): GSFC, JPL

Earth is a complex, dynamic system we do not yet fully understand. We need to understand the Earth's atmosphere, lithosphere, hydrosphere, cryosphere, and biosphere as a single connected system. The purpose of NASA's Earth science program is to develop a scientific understanding of Earth's system and its response to natural or human-induced changes, and to improve prediction of climate, weather, and natural hazards. A major component of NASA's Earth Science Division is a coordinated series of satellite and airborne missions for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans. This coordinated approach enables an improved understanding of the Earth as an integrated system. NASA is completing the development and launch of a set of Foundational missions, new Decadal Survey missions, and Climate Continuity missions. This subtopic seeks innovative laser transmitters and receivers to allow accurate measurements of atmospheric parameters with high spatial resolution from ground and airborne platforms. These developments require advances in the state-of-the-art lidar technology with emphasis on compactness, efficiency, reliability, lifetime, and high performance. This subtopic is seeking only the innovative laser transmitter subsystem or complete receiver subsystem for the three listed areas, which upon delivery would be infused into a lidar system demonstration. *(Individual lidar components are NOT solicited in this subtopic but can be submitted under theS1.01 Lidar Remote Sensing Technologies)* With the larger funded effort, NASA seeks to have delivered a full transmitter or receiver subsystem with turnkey operation meeting the requirements of one of the three targeted areas below. The selected proposal(s) will be required to work closely with the NASA customers to understand performance requirements.

- *Tunable laser system development for water vapor DIAL systems* for *high altitude aircraft platforms* - Need: climate, upper-troposphere, lower-stratosphere, cirrus cloud, and satellite validation studies. Application from high altitude platforms (35,000 to 65,000 ft). Water vapor in the high altitudes impacts climate, radiation, stratospheric /tropospheric exchange, and even impacts satellite validation activities. There is a critical need for high accuracy, high resolution water vapor measurement and its impact at the highest altitudes. The most critical unmet need for a high-altitude a water vapor DIAL system is a compact, rugged, and efficient tunable laser transmitter to operate on one of the strong H2O absorptions lines near 934.55, 935.43 or 944.11 nm (H2O line center). Tunability over the side of the line up to 100 pm is needed. Need to demonstrate the laser can operate locked at 0 pm, 25 pm, 50 pm, and 100 pm from line center position of the H2O line at low pressure. Frequency stability of <0.1 pm and linewidths of <0.2 pm are required. High spectral purity >99.9% need to be demonstrated. Ability to switch between wavelengths within 300 micro second is needed. Pulse energies in the range 5 to 100 mJ with output power of 2-5 W (low pulse energies will require higher average power to overcome background and detector noise issues). (Note for later spacecraft application 50 mJ - 500 mJ and output power ~ 10 W would be needed).
- *Compact, rugged laser transmitter for advanced ozone DIAL lidar systems* - NASA and other agencies have a long-term interest in lidar profile measurements of atmospheric ozone from the ground and also from aircraft. A measurement goal would be ± 5 ppb ozone throughout the troposphere. Major technology

advances are needed to allow multiple ozone lidar stations to make continuous ozone profile measurements over extended time intervals. Laser transmitters are needed that simultaneously (or interleaved) produce three eye-safe ultraviolet wavelengths (preferably tunable) between approximately 280 and 316 nm with approximately 1-nm linewidth. Laser pulses would typically be less than 100-nsec in pulsewidth with ~2 Watts power in each of 3 UV wavelengths. Both high (~1kHz) and low (~20Hz) repetition rate lasers will be considered. Such a system would be required to operate reliably for extended times with a minimum of expendable supplies and be easily transportable. The total instrument volume would be approximately one square meter. The laser system is targeted for infusion in a ground system demonstration.

- *Atmospheric Lidar with Cross-Track Coverage* - A key measurement capability for NASA Earth Science applications is lidar remote sensing of atmospheric clouds and aerosols and, increasingly, cloud-aerosol interactions. The vertical resolution possible with lidar systems provides accurate identification of cloud and aerosol layer heights and structure. However, a primary limitation of existing lidar instruments is lack of horizontal (e.g., cross-track) coverage. Technologies are solicited for transmitter, transceiver, or receiver technologies that enable airborne lidar measurements of clouds and aerosols having both vertical and horizontal extent. Technologies are sought that demonstrate a capability that can be mounted on a relevant high-altitude aircraft platform (specifically, ER-2, Global Hawk, or Proteus). The ability of any proposed technology to be scalable to spaceborne application is highly desirable. The focus is on cloud and aerosols (and cloud-aerosol interaction); proposals specific to scanning/mapping surface altimetry will be considered nonresponsive. Funds available permit development of instrument subsystems. Depending on the approach chosen, the subsystem might be a novel transmitter, transceiver, or a scanner/receiver subsystem. Regardless of the subsystem developed, it is essential that the proposer demonstrate how their subsystem can be integrated into a complete instrument. That is, developing a novel scanning technology that cannot be easily or affordably coupled to a transmitter would be of little use. The successful proposal(s) will demonstrate consideration of the end-to-end instrument design, including demonstration that the system envisioned would be capable of obtaining sufficient signal over required averaging volumes (e.g., demonstrate simulation capability sufficient to convince reviewers that the resultant measurement will be useful).

Although different approaches might be proposed, and different subsystems or types of subsystems are possible, general guidance on requirements include:

- Profiling of cloud and aerosol backscatter, with emphasis on multiple wavelengths and depolarization measurement capability, if possible.
- Horizontal coverage of at least ± 5 km, with horizontal resolution < 1 km. Therefore, the system design should have at least 10 cross-track points, and more if possible.
- Along-track resolution will be driven by the specific technology proposed, but in general, along-track integration times of < 2 seconds is preferred.
- Vertical resolution can be driven by the detector(s) and data system, but nominal vertical resolution of < 100 m is desirable. System designs should be sized appropriately to obtain sufficient signal over these vertical and horizontal resolutions.
- It is desirable to utilize solid-state (e.g., photon-counting) detection if possible. Data systems can be readily obtained to interface with photon-counting detectors, thereby lowering the cost and complexity of a completed instrument.
- Size, mass, power constraints need to be considered and should be commensurate with accommodations of the NASA ER-2, Global Hawk, or Proteus aircraft. In general, the airborne platforms will limit the transceiver aperture size. Thermal, pressure, and other environmental constraints of these high-altitude airborne platforms should also be considered.

Successful proposals will demonstrate an understanding of the relevant science need, and present a feasible plan to work with a NASA sponsor to use follow-on funding opportunities to develop a complete airborne instrument. Follow-on opportunities include, but are not limited to Instrument Incubator Program (IIP), Airborne Instrument Technology Transition (AITT), Earth Venture - Instrument (EV-I), or Phase III SBIR funding. The Phase I research activity should demonstrate technical feasibility during and show a clear path to a Phase II prototype. The Phase II deliverable should be packaged in such a manner that it can be directly infused into follow-on opportunities to develop a complete lidar instrument.